

MESOSMITTIA BRUNDIN FROM CHINA (DIPTERA, CHIRONOMIDAE)

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Abstract *Mesosmittia* Brundin from China including is reviewed. Three new species, *M. absensis* sp. nov., *M. brevis* sp. nov. and *M. gracilis* sp. nov. are described and figured. *M. acutistyla* Sæther is recorded from China for the first time. Key to the males of *Mesosmittia* from China is also provided.

Key words Chironomidae, *Mesosmittia*, new species, key, China.

1 Introduction

The genus *Mesosmittia* was erected by Brundin (1956) for *Spaniotoma* (*Orthocladus*) *flexuella* Edwards, 1929. The genus is cosmopolitan, and was revised by Sæther (1985) with six Nearctic and one Neotropical species. Sæther (1996) described an additional species from Africa, recorded *M. patrihortae* Sæther for the first time in Africa and additionally transferred a previously described species to *Mesosmittia*, *M. nigerrima* (Kieffer). Andersen and Mendes (2002) added four species from Mexico and the Neotropical Regions. So far, 14 species have been recognized all over the world, among which 2 species from Palearctic Region, 6 species from the Nearctic Region, 10 species from the Neotropical Region, 3 species from the Afrotropical Region, 1 species from the Oriental Region (Sæther, 1985, 1996; Cranston *et al.*, 1989; Caldwell *et al.*, 1997; Wang, 2000; Andersen & Mendes, 2002; Yamamoto, 2004; Yamamoto, 2008).

Wang and Zheng (1990) described two species from China, *M. dolichoptera* and *M. yunnanensis*, that were synonymized by Sæther (1996) with *M. patrihortae*. In the Chinese chironomids checklist (Wang, 2000), *M. dolichoptera* had been treated as a synonym of *M. patrihortae*, but *M. yunnanensis* was kept as a valid species. Based on a reexamination of the material from China, *M. yunnanensis* is considered as a junior synonym of *M. patrihortae*, and three new species from Palearctic and Oriental China are described and illustrated as male adults.

A key to the males of *Mesosmittia* from China is also provided.

2 Material and Methods

The material examined was mounted on slides following the procedure outlined by Sæther (1969). The morphological nomenclature follows Sæther

(1980). Measurements are given as ranges followed by the arithmetic mean, when three or more measurements were taken, followed by the number of individuals (*n*) in parentheses. All the types described in this paper are deposited in the College of Life Sciences, Nankai University, China (BDN).

3 Species Description

3.1 *Mesosmittia acutistyla* Sæther

Mesosmittia acutistyla Sæther, 1985: 43.

Material examined. 1 ♂, Hebei Province, Chicheng County, Luhebao Village, 21 July 2001, sweep net, GUO Yu-Hong. (BDN No. 23526).

Diagnostics. The adult male can be separated from all other members of the genus by the shape of the gonostylus (widest at the base).

Remarks. The specimen from China conforms with the description given by Sæther (1985) for most of characters, except for the antennal ratio (1.34 against 1.48 in the original description).

Distribution. This species has been recorded from U. S. A. and Mexico (Sæther, 1985; Andersen & Mendes, 2002), this constitutes the first record from the Palearctic Region (Shannxi Province).

3.2 *Mesosmittia absensis* sp. nov. (Figs 1–2)

Holotype ♂, China, Shannxi Province, Zhouzhi County, Banfangzi Town, 9 Aug. 1994, sweeping net, BU Wen-Jun. (BDN No. 03854).

Diagnostics. The adult male can be separated from all other members of the genus by having a short gonostylus and without megaseta. AR about 1.0.

Etymology. From Latin, *absens*- means lacking or absent, referring to the absence of the megaseta.

Adult male (*n* = 1). Total length 1.95 mm. Wing length 1.10 mm. Total length / wing length 1.77. Wing length / profemur length 2.59.

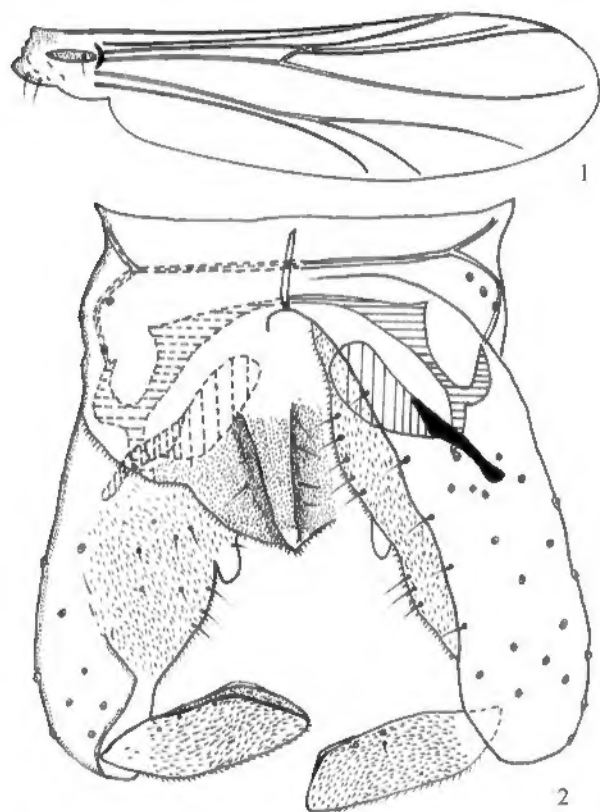
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Table 1. Lengths (in μm) and proportions of legs segments of male *M. absensis* sp. nov.

	P ₁	P ₂	P ₃
fe	425	430	470
ti	540	460	520
ta ₁	260	190	300
ta ₂	160	110	160
ta ₃	105	80	120
ta ₄	70	50	70
ta ₅	55	50	60
LR	0.48	0.41	0.58
BV	3.71	4.68	3.3
SV	3.14	3.61	3.15
BR	1.75	2.19	3

Figs 1–2. *Mesosmittia absensis* sp. nov. 1. Wing. 2. Hypopygium.

Coloration. Head yellowish brown with brown antennae, thorax dark brown, abdomen and leg brown.

Head. AR 1.01. Ultimate flagellomere 312 μm long. Temporal setae 4, including 2 inner and 2 outer verticals postorbitals. Clypeus with 15 setae. Tentorium 119 μm long, 22 μm wide. Palpomere lengths (in μm): 25; 48; 73; 68; 113. L: 5th/3rd 1.54.

Thorax. Anteprenotum with 3 setae; dorsocentrals 9; acrostichals about 6; prealars 4; scutellum with 6 setae.

Wing (Fig. 1). VR 1.24. Costal extension 17 μm long. Squama with 2 setae. All veins bare except brachiolium with 1 seta.

Legs. Spur of front tibia 31 μm long; spurs of mid tibia 13 μm and 15 μm long; of hind tibia 26 μm and 28 μm long. Comb with 10 setae, shortest seta 25 μm long, longest seta 38 μm long. Width at apex of front tibia 26 μm , of mid tibia 22 μm , of hind tibia 31 μm . Lengths (in μm) and proportions of legs as in Table 1.

Hypopygium (Fig. 2). Tergite IX longitudinal ridge with 6 marginal setae, laterosternite IX with 4 setae. Phallapodeme 38 μm long; transverse sternapodeme 51 μm long. Virga 20 μm long. Gonocoxite 155 μm long, gonostylus short, 70 μm long. Megaseta absent. HR 1.89, HV 2.79.

Remarks. This species, together with *M. brevis* sp. nov., lacks a megaseta on the gonostylus, and can be separated from *M. breviae*, based on the AR of about 1.00 against an AR above 1.40 in *M. brevis*.

Distribution. Shannxi Province, Zhouzhi County.

3.3 *Mesosmittia brevis* sp. nov. (Figs 3–4)

Holotype δ , China, Hebei Province, Zunhua County, Longmenkou reservoir area, 7 July 2001, sweep net, GUO Yu-Hong. (BDN No. 23272). Paratypes 4 δ , same data as holotype (BDN).

Diagnostic characters. The adult male has a comparative shorter gonostylus which can be separated from all other members of the genus except *M. absensis* sp. nov. and *M. tora* Sæther, while *M. absensis* sp. nov. has no megaseta and *M. tora* with well developed inferior volsella.

Etymology. From Latin, *brev-* means short, referring to the short gonostylus.

Adult male ($n = 5$). Total length 1.78–2.10, 1.95 mm. Wing length 1.03–1.13, 1.09 mm. Total length / wing length 1.69–1.91, 1.80. Wing length / profemur length 2.27–2.62, 2.49.

Coloration. Head brown, thorax and abdomen blackish brown, wing nearly transparent.

Head. AR 1.40–1.54, 1.50. Ultimate flagellomere 365–430, 392 μm long. Temporal setae 5–8, 6 including 2–4, 3 inner and 3–5, 4 outer verticals. Clypeus with 12–14, 13 setae. Tentorium 101–106, 103 μm long, 13–17, 15 μm wide. Palpomere lengths (in μm): 17–22, 18; 31–40, 36; 53–57, 56; 48–61, 54; 79–97, 87. L: 5th/3rd 1.39–1.69, 1.55.

Thorax. Anteprenotum with 1–3, 2 setae; dorsocentrals 7–10, 9; acrostichals 9–14, 11; prealars 4–6, 5; scutellum with 6–9, 8 setae.

Wing (Fig. 3). VR 1.22–1.29, 1.25. Costal extension 15–24 μm long. Squama with 1–4, 2

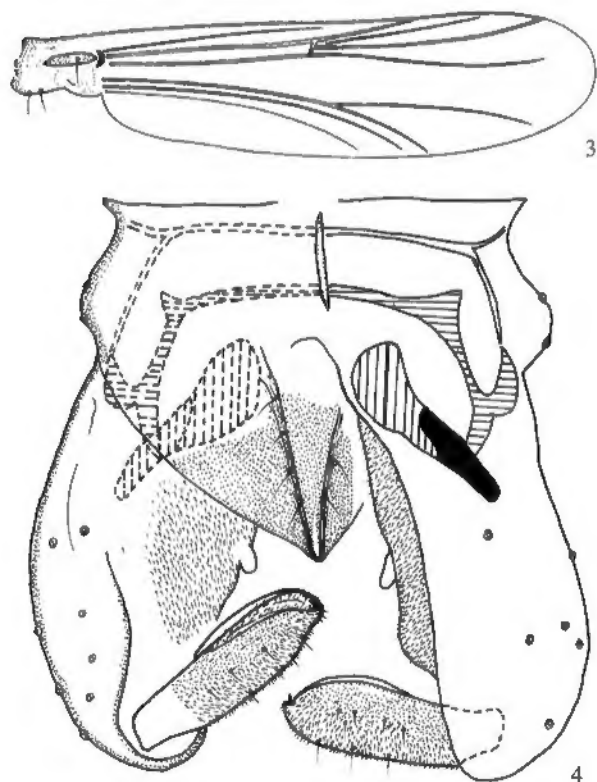
setae. R with 0–2, 0 setae. Brachiolium with 1 setae.

Legs. Spur of front tibia 24–35, 32 μm long; of mid tibiae 13–17, 16 μm and 12–15, 13 μm long; of hind tibia 31–35, 32 μm and 9–13, 12 μm long. Comb with 10–13, 11 setae, shortest seta 18–23, 20 μm long, longest seta 30–33, 31 μm long. Width at apex of front tibia 22–26, 24 μm , of mid tibia 22–25, 23 μm , of hind tibia 26–33, 28 μm . Lengths (in μm) and proportions of legs as in Table 2.

Hypopygium (Fig. 4). Tergite IX with 3–7, 5 weak setae, laterosternite IX with 4–7, 5 setae. Phallapodeme 38–45, 42 μm long; transverse sternapodeme 75–90, 82 μm long. Virga 28–38, 34 μm long. Gonocoxite 119–128, 125 μm long. Gonostylus short, nearly rectangular-shaped, 62–70, 66 μm long, with low crista dorsalis. Megaseta 5 μm long. HR 1.83–1.94, 1.90, HV 2.69–3.07, 2.95.

Remarks. This new species is similar to *M. absensis* sp. nov. and *M. tora* Sæther in having short gonostylus which less than 70 μm long, but *M. apsenis* sp. nov. without megaseta and with lower antennal ratio (AR 1.0) than *M. brevae* sp. nov. (AR about 1.5). *M. tora* has well developed inferior volsella, while *M. brevae* sp. nov. is opposite.

Distribution. Hebei Province.



Figs 3–4. *Mesosmittia absensis* sp. nov. 3. Wing. 4. Hypopygium.

Table 2. Lengths (in μm) and proportions of legs segments of male *M. brevae* sp. nov.

	P ₁	P ₂	P ₃
fe	400–460, 432	420–470, 460	460–510, 500
ti	470–560, 530	410–500, 486	510–580, 560
ta ₁	220–280, 248	180–210, 194	260–340, 306
ta ₂	130–160, 144	100–120, 108	140–170, 159
ta ₃	90–110, 102	70–85, 82	100–140, 134
ta ₄	70–80, 73	40–60, 53	60–70, 67
ta ₅	50–60, 58	40–60, 53	50–65, 60
	0.41–0.49, 0.47	0.38–0.43, 0.40	0.50–0.59, 0.54
BV	3.39–4.30, 3.96	4.48–5.11, 4.85	3.21–3.73, 3.46
	3.00–3.49, 3.21	3.64–4.51, 3.91	3.02–3.61, 3.30
BR	1.29–2.17, 1.87	1.88–2.50, 2.20	2.92–4.06, 3.31

3.4 *Mesosmittia gracilis* sp. nov. (Figs 5–6)

Holotype ♂, China, Gansu Province, Tianshui City, Mt. Xiaolong, 7 Aug. 1993, sweep net, BU Wen-Jun (BDN No. 08259).

Diagnostic. The adult male gonostylus widest medially, and the shape of the virga will separate *M. gracilis* from all other *Mesosmittia*.

Etymology. From Latin, *gracilis* means slender, refers to the shape of the virga.

Adult male ($n = 1$). Total length 2.23 mm. Wing length 1.1 mm. Total length / wing length 2.02. Wing length / profemur length 2.29.

Coloration. Head and thorax dark brown, abdomen, leg yellowish brown.

Head. AR 1.35. Ultimate flagellomere 440 μm long. Temporal setae 7 including 3 inner and 4 outer verticals. Clypeus with 12 setae. Tentorium 110 μm long, 22 μm wide. Palpomere lengths (in μm): 22; 44; 84; 79; 123. L: 5th / 3rd 1.47.

Thorax. Antepronotum with 1 setae; dorsocentrals 9; acrostichals 12; prealars 5; scutellum with 8 setae.

Wing (Fig. 5). VR 1.22. Costal extension 30 μm long. R with 1 setae. Squama with 4 setae. Brachilous with 1 setae.

Legs. Spur of front tibia 42 μm long; of median tibiae 23 μm and 17 μm long; of hind tibia 30 μm and 15 μm long. Comb with 14 setae, shortest seta 20 μm long, longest seta 25 μm long. Width at apex of front tibia 25 μm , of middle tibia 20 μm , of hind tibia 21 μm . Lengths (in μm) and proportions of legs as in Table 3.

Hypopygium (Fig. 6). Tergite IX with 9 setae, laterosternite IX with 7 setae. Phallapodeme 40 μm long; transverse sternapodeme 75 μm long. Virga very slender, 66 μm long. Gonocoxite 165 μm long. Gonostylus 80 μm long, widest in nearly median. Megaseta 5 μm long. HR 2.06, HV 2.78.

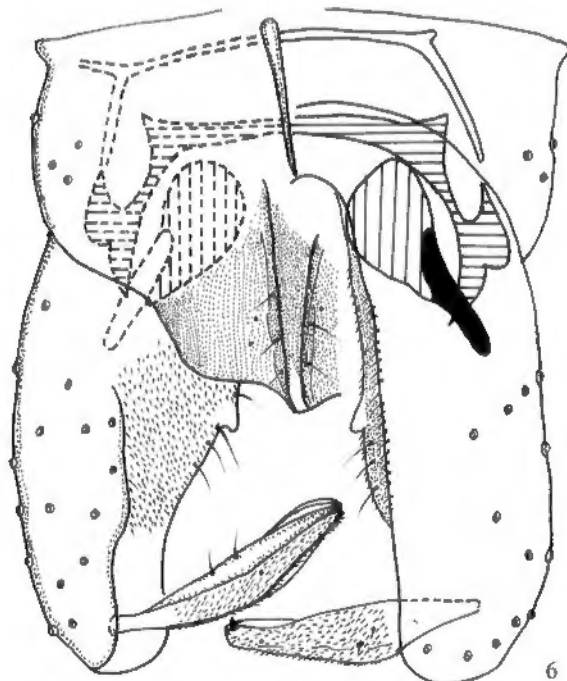
Remarks. This species is closed to *M. guanajensis*

Andersen & Mendes in both having tapering gonostylus. But *M. gracilis* sp. nov. can be separated by having a slender virga and higher palp L: 5th/3rd (1.47), while L: 5th/3rd in *M. guanjensis* is 1.33. Besides, *M. acutistyla* Sæther also has a tapering gonostylus which widest basally, while *M. gracilis* widest in nearly median.

Distribution. Gansu Province.

Table 3. Lengths (in μm) and proportions of legs segments of male *M. gracilis* sp. nov.

	P ₁	P ₂	P ₃
fe	480	470	490
ti	600	520	600
ta ₁	280	200	330
ta ₂	190	120	170
ta ₃	130	90	150
ta ₄	90	60	70
ta ₅	70	60	60
LR	0.47	0.38	0.55
BV	2.83	3.61	3.61
SV	3.86	4.95	3.3
BR	1.87	2	2.2



Figs 5–6. *Mesosmittia gracilis* sp. nov. 5. Wing. 6. Hypopygium.

3.5 *Mesosmittia patrihortae* Sæther

Mesosmittia patrihortae Sæther, 1985: 47; Sæther, 1996: 290. Andersen & Mendes, 2002: 150.

Mesosmittia dolichoptera Wang & Zheng, 1990: 486.

Mesosmittia yunnanensis Wang & Zheng, 1990: 488; Wang, 2000: 637.

Material examined. 23 ♂♂, Yunnan Province, Wuding County, Shizi Mountain, 6 Aug. 1986, sweep net, WANG Xin-Hua; 2 ♂♂, Guizhou Province, Dashahe Natural Conservation Area, 24 Aug. 2004, sweep net, YU Xin; 4 ♂♂, Guizhou Province, Guiyang City, Huaxi Park, 25 July 2001, light trap, GUO Yu-Hong; 6 ♂♂, Hebei Province, Zunhua City, Longmenkou Reservoir, 7 July 2001, sweep net, GUO Yu-Hong; 3 ♂♂, Hubei Province, Lifeng County, Hou River, 10 July 1999, sweep net, JI Bing-Chun; 10 ♂♂, Hubei Province, Xianfeng County, Pingbaying Forest, 1 July 1999, sweep net, JI Bing-Chun; 3 ♂♂, Hubei Province, Xianfeng County, Maheba Village, 25 July 1999, sweep net, JI Bing-Chun; 3 ♂♂, Hubei Province, Hefeng County, Fenshuiling Forestry, 17 July 1999, sweep net, JI Bing-Chun; 3 ♂♂, Shannxi Province, Zhouzhi County, Banfangzi Town, 9 Aug. 1994, sweep net, BU Wen-Jun; 6 ♂♂, Shannxi Province, Xifeng County, Tsinling Mountain, 28 July 1994, sweep net, BU Wen-Jun; 1 ♂, Shannxi Province, Ningshan County, Xunyangba Town, 17 Aug. 1994, sweep net, LU Nan; 1 ♂, Shannxi Province, Liuba County, Miaotaizi Village, 17 July 1994, sweep net, BU Wen-Jun; 22 ♂♂, Guangxi Autonomous Region, Leye Forestry, 24 July 2004, sweep net, YU Xin; 21 ♂♂, Sichuan Province, Wolong Natural Conservation Area, 27 July 1987, sweep net, WANG Xin-Hua; 8 ♂♂, Gansu Province, Tianshui City, Maji Mountain, 5 Aug. 1986, sweep net, WANG Xin-Hua; 2 ♂♂, Yunnan Province, Fumin County, Daying Town, 1 June 1996, sweep net, WANG Xin-Hua; 8 ♂♂, Jilin Province, Changbaishan Natural Conservation Area, 23 June 1986, sweep net, WANG Xin-Hua; 2 ♂♂, Tianjin City, Yangliuqing Farm, 10 Aug. 1985, sweep net, WANG Xin-Hua; 3 ♂♂, Shandong Province, Muping County, Yulindian Town, 28 Aug. 1988, sweep net, WANG Xin-Hua; 1 ♂, Sichuan Province, Wenchuan County, 14 July 1987, sweep net, WANG Xin-Hua; 2 ♂♂, Sichuan Province, Ganzi Autonomous County, Yajiang River, 14 June 2001, sweep net, WANG Xin-Hua; 1 ♂, Sichuan Province, Yingxiu County, 15 July 1987, sweeping net, WANG Xin-Hua; 1 ♂, Yunnan Province, Kunming City, Songhuaba Reservoir, 1 June 1996, light trap, WANG Xin-Hua; 1 ♂, Guizhou Province, Daozhen County, Dashahe Natural Conservation Area, 25 May 2004, light trap, TANG Hong-Qu; 1 ♂, Jiangsu Province, Nanjing University campus, sweep net, BU Wen-Jun; 1 ♂, Chongqing City, Jinfo Mountain, sweep net, WANG

Xin-Hua; 4 ♂♂, Henan Province, Luanchuan County, Miaozi Town, 12 June 1996, sweep net, LI Jun; 3 ♂♂, Yunnan Province, Kunming City, Heilongtan Park, 20 May 1996, sweep net, WANG Xin-Hua; 3 ♂♂, Guizhou Province, Luodian County, 9 Aug. 1995, sweep net, BU Wen-Jun; 2 ♂♂, Yunnan Province, Dali City, 23 May 1996, sweep net, WANG Xin-Hua. Diagnostic. The adult male can be separated from all other members of the genus by having club-shaped gonostylus, inferior volsella more or less developed.

Remarks. The species has been described in detail by Sæther (1985). Most of the characters in examined specimen from China are identical to original description. There are some variations in AR and the seta number in squama can be found. 3 specimen from Shannxi Province with AR 1.04 – 1.10, 1 specimen from Hubei Province with AR 1.70, 9 from Hubei Province with 4 – 8 squama setae. Thus, the AR of the species is from 1.04 – 1.70, the seta number of squama is 1 – 8.

Wang and Zheng (1990) described two new species, *Mesosmittia dolichoptera* and *Mesosmittia yunnanensis* from China. Later, Sæther (1996) and Andersen & Mendes (2002) treated them as a junior synonym of *M. patrihortae*. In the checklist of chironomids from China, Wang (2000) lists *M. yunnanensis* as a separate valid species. Recently, we re-examined these two type specimens, and considered both are synonyms of *M. patrihortae*.

Distribution. The species has a cosmopolitan distribution. It has been recorded from U. S. A., Brazil, Costa Rica, Ecuador, Venezuela, South Africa, Mexico and Japan (Sæther, 1985, 1996; Andersen & Mendes, 2002; Yamamoto, 2008). It occurs in both Oriental (Yunnan, Guizhou, Hubei, Guangxi, Sichuan, and Shannxi Province) and Palaearctic China (Hebei, Gansu, Jilin, Shandong Province and Tianjin City).

Key to adult Chinese species of *Mesosmittia* (male).

1. Gonostylus not or at most slightly tapering 2
Gonostylus tapering, widest basally or medially 4
2. Megaseta absent *M. absensis* sp. nov.
Megaseta present 3

3. Gonostylus shorter than 70 µm long, nearly rectangular-shaped ...
..... *M. brevis* sp. nov.
Gonostylus longer than 70 µm long, club-shaped
..... *M. patrihortae* Sæther
4. Gonostylus tapering from base to apex, widest basally
..... *M. acutistyla* Sæther
Gonostylus widest in nearly median *M. gracilis* sp. nov.

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REFERENCES

- Andersen, T. and Mendes, H. F. 2002. Neotropical and Mexican *Mesosmittia* Brundin, with the description of four new species (Insecta, Diptera, Chironomidae). *Spixiana*, 25: 141 – 155.
- Brundin, L. 1956. Zur Systematik der Orthocladinae (Dipt., Chironomidae). *Reports from the Institute of Freshwater Research, Drottningholm*, 37: 5 – 185.
- Caldwell, B. A., Hudson, P. L., Lenat, D. R. and Smith, D. R. 1997. A revised annotated checklist of the Chironomidae (Insecta: Diptera) of the Southeastern United States. *Transactions of the Royal Entomological Society of London*, 123: 1 – 53.
- Cranston, P. S., Oliver, D. R. and Sæther, O. A. 1989. The adult males of Orthocladinae (Diptera: Chironomidae) of the Holarctic Region. Keys and diagnoses. In: Wiederholm, T. (ed.), Chironomidae of the Holarctic region. Keys and diagnoses. Part 3. Adult males. *Entomologica Scandinavica Supplement*, 34: 165 – 352.
- Sæther, O. A. 1969. Some Nearctic Podonominae, Diamesinae, and Orthocladinae (Diptera: Chironomidae). *Bulletin of the Fisheries Research Board of Canada*, 170: 1 – 154.
- Sæther, O. A. 1980. A glossary of chironomid morphology terminology (Diptera: Chironomidae). *Entomologica Scandinavica Supplement*, 14: 1 – 51.
- Sæther, O. A. 1985. The imagines of *Mesosmittia* Brundin, 1956, with description of seven new species (Diptera, Chironomidae). *Spixiana Supplement*, 11: 37 – 54.
- Sæther, O. A. 1996. Afrotropical records of the orthoclad genus *Mesosmittia* Brundin (Insecta, Diptera, Chironomidae). *Spixiana*, 19: 289 – 292.
- Wang, X and Zheng, L. 1990. Two new species of *Mesosmittia* from China (Diptera: Chironomidae) (in Chinese with English summary). *Acta Entomologica Sinica*, 33: 486 – 489.
- Wang, X. 2000. A revised checklist of Chironomidae from China (Diptera). In: Hoffrichter, O. (ed.), Late 20th Century Research on Chironomidae. An Anthology from the 13th International Symposium on Chironomidae. Shaker Verlag, Aachen. pp. 629 – 652.
- Yamamoto, M. 2004. A catalog of Japanese Orthocladinae (Diptera: Chironomidae). *Acta Dipterologica*, 21: 1 – 121.
- Yamamoto, M. 2008. Redescription of *Mesosmittia patrihortae* Sæther, 1985, from Japan (Diptera, Chironomidae). *Japanese Journal of Systematic Entomology*, 14: 13 – 16.

中国肛脊摇蚊属记述 (双翅目, 摇蚊科)

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摘 要 记述中国肛脊摇蚊属 5 种, 包括 3 新种 *M. apsensis* sp. nov., *M. brevae* sp. nov. 和 *M. gracila* sp. nov., 中国 1 新记录种 *M. acutistyla* Sæther。编制了中国该属 5 种雄虫检索表。模式标本保存于南开大学生命科学学院摇蚊学研究室。

无棘肛脊摇蚊, 新种 *M. apsensis* sp. nov. (图 1~2)

雄成虫与本属其它已知种的区别如下: 抱器端节不具亚端背脊, 触角比 (AR) 约为 1.0。

正模 ♂, 陕西省周至县板房子乡, 1994-08-09, 扫网, 卜文俊采。

短肛脊摇蚊, 新种 *M. brevae* sp. nov. (图 3~4)

雄成虫与本属其它已知种的区别如下: 雄成虫具有相对

关键词 摇蚊科, 肛脊摇蚊属, 新种, 检索表, 中国。

中图分类号 Q969.442.6

短的抱器端节可以将其与该属除了 *M. absensis* sp. nov. 和 *M. tora* Sæther 之外的其它种分开, 但是 *M. absensis* sp. nov. 不具有亚端背脊, *M. tora* 则具有发达的下附器。

正模 ♂, 河北省遵化市龙门口水库, 2001-07-07, 扫网, 郭玉红采。副模 4 ♂♂, 同正模。

纺锤肛脊摇蚊, 新种 *M. gracila* sp. nov. (图 5~6)

雄成虫与本属其它已知种的区别如下: 雄成虫的抱器端节中部最宽, 阴茎刺突细长。

正模 ♂, 甘肃省天水市小陇山, 1993-08-07, 扫网, 卜文俊采。

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